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# A PETITION TO IMPORT *BRUCHIDIUS VILLOSUS* FROM NO.CAROLINA TO THE WESTERN U.S. FOR BIOLOGICAL CONTROL OF SCOTCH BROOM (*CYTISUS SCOPARIUS*)

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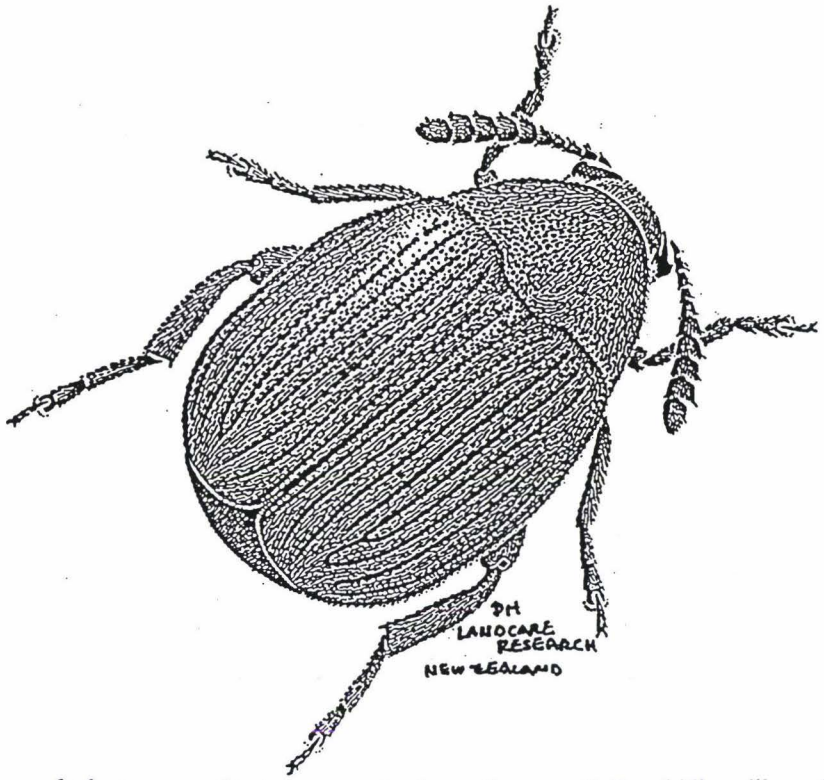
# A PETITION TO IMPORT *BRUCHIDIUS VILLOSUS* FROM NORTH CAROLINA TO THE WESTERN U.S. FOR BIOLOGICAL CONTROL OF SCOTCH BROOM (*CYTISUS SCOPARIUS*)




A request is hereby made for approval to import and release the weevil, *Bruchidius villosus* (Fabricius) (Copeoptera: Bruchidae), for biological control of Scotch broom, *Cytisus scoparius* (L.)Link. Several studies of the weevil are complete. These include oviposition experiments by New Zealand researchers and by Dr. Jeff Littlefield at Montana State University in Bozeman, MT. Identification studies were conducted by the USDA-ARS Systematic Entomology Laboratory/Taxonomic Services Unit, by Dr. Robert Nowierski at Montana State University and by CAB International's International Institute of Entomology in London, U.K. Earlier studies of both oviposition and identity of *B. villosus* at several locations also were discovered.

Weevils would be field collected in 1998 and 1999 in North Carolina and shipped to the quarantine facility at Montana State University to be held for observation and testing for parasites and pathogens. Assuming favorable results of these observations and tests, adult weevils would be shipped to the Noxious Weed Control Program at the Oregon Department of Agriculture (ODA), Salem, Oregon, and jointly released by ODA and personnel from the Mapleton District of the U.S. Forest Service and representatives of the Rocky Mountain Research Station of the U.S. Forest Service on land administered by the Siuslaw National Forest within the Mapleton District during 1998 and 1999. Releases will be jointly monitored by a technician employed at the Mapleton District with support from the Rocky Mountain Research Station and ODA.

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# I. Petition Introduction

## A. Taxonomic Issues

**1. Identification of *Bruchidius villosus*.**
*Bruchidius villosus* is a European species, introduced into the U.S. In 1918 a *Bruchidius* reared from Scotch broom was thought to be the native Bruchid, *Bruchus calvus*, but later the collection was identified as *Bruchidius ater*, and then later re-identified as *B. villosus* (Bottimer 1968). Southgate (1963) reevaluated the type specimens of several early American collections of Bruchids and determined that the early collections were *B. ater*, and that *B. ater* was distinct from *B. villosus*. New Zealand researchers synonymized *B. ater* and *B. villosus* (Syrett & O'Donnell 1987). Because of the confusing history of the identification of the introduced species of Bruchidae attacking Scotch broom in the eastern U.S., three separate approaches to the identification of the agent proposed for introduction herein are reported.

**2. Relationship of Scotch broom to protected plant species.**
Scotch broom belongs to a group comprised entirely of introduced European species. The most closely related plants of concern are in another Subtribe, the Lupineae, usually placed in the Tribe Genistaea. Because there are protected species within the Lupineae, the relationship of western lupines to Scotch broom are explained in Section II.B. in detail.

## B. Other issues

**1. The need for a petition.**
Technically there is no need for a formal petition to import *B. villosus* from North Carolina and to release it into Oregon. A USDA-APHIS-PPQ Form 526 approval by the Plant Division of the Oregon Department of Agriculture is the only requirement. If, however, *B. villosus* establishes, it is likely that it will eventually disperse to California, Washington, British Columbia, and perhaps even to western states with smaller broom infestations. This petition is organized so that all the factors normally considered for intercontinental movement of biological control agents are included, and the format is similar to that recommended in the USDA-APHIS-PPQ "Reviewer's Manual for the Technical Advisory Group for Biological Control Agents of Weeds," even though consideration by TAG is not anticipated.

**2. Compatibility of *B. villosus* with *Apion fuscirostre*.**
This proposal is to import and release one seed-attacking species when another, the weevil *Apion fuscirostre* (Coleoptera: Curculionidae), is already established. Older research suggests that direct competition between *B. villosus* and *A. fuscirostre* may occur only at very high levels of attack, and new research suggests that reduction of seed production to the lowest possible levels may be required. This work is discussed in Sections II.E. and III.E.

# II. Target Weed Information

## A. Targeting of Scotch broom for biological control.

### 1. Earlier targeting.

Discussion of Scotch broom as a target for biological control is mentioned in an unpublished report of the Insect Identification and Parasitic Introduction Section of the Entomology Research Branch of the USDA dated October 1, 1954. In a memorandum dated November 10, 1959, W.B. Ennis, USDA-ARS Crops Research Division, and Chairman of the Subcommittee on Biological Control of Broom, reported that the Subcommittee had unanimously "...reached a decision that Scotch broom is an economic pest in California and ... recommend(ed) that biological control of Scotch broom with insects be undertaken..." Broom was then not considered serious enough, or invading fast enough, to be considered a serious pest in Oregon, Washington and British Columbia.

### 2. Current status of Scotch broom as a weed.

Scotch broom is now regarded as a pest, by being listed on noxious weed lists, not only in California, but also in Washington and Oregon. It is included in an Extension Service bulletin in Idaho (Callihan and Miller 1994) and generally regarded as a pest in British Columbia. It is listed on the "All States' Noxious Weed Seed List" maintained by the USDA Agricultural Marketing Service's Seed Regulatory and Testing Branch. Formerly regarded as a species best adapted to coastal climates, broom grows to maturity in five eastern Oregon counties and in Idaho and Montana. Its range is expanding, and densities of broom within its established range is also increasing. It is regarded as a principle pest in New Zealand and as a common weed in Hawaii and Iran (Holm et al. 1979).

At a symposium on Scotch broom held April 17-18, 1996 in Portland, Oregon, there was no dissent when two of several workgroups recommended re-initiating research into biological control of Scotch broom, and there was a clear consensus among attendees, from several states and representatives of local, state and federal government organizations, and the private sector that action was needed to reduce the impacts of broom.

## B. Taxonomy of Scotch broom and related plants.

Scotch broom is a member of the legume family, which has about 650 genera and perhaps 18,000 species and is the third largest family after composites and orchids (Pohill et al. 1981). The family contains species as different as robust trees and delicate annuals, and succeeds in a wide range of habitats throughout the world. Many species fix nitrogen, and a large number are significant as sources of food for humans and animals.

The taxonomic position of Scotch broom:

| | |
|---|---|
| Family: | Fabaceae Lindl., nom. cons. (1836) |
| Subfamily: | Papilionideae (after Isley & Polhill ) |
| Tribe: | Genistaea (Adans.) Benth. |
| Subtribe: | Cytisus-Genista (after Bisby, 1981) |
| Genus: | *Cytisus* Link. (Sarothamnus Wimmer syn.) |
| Species: | *scoparius* L. |

Organization within the Fabaceae and the Papilionoideae is complex, and several different techniques have been used in attempts at determining relationships. Early phylogenies were based almost entirely on morphology (Polhill *et al.* 1981, Hutchinson 1964). More recently, Yong-Ming and Ze-Xiang (1990) used morphology to describe the relationships of the Tribe Thermopsideae, and Lavin and Doyle (1990) used pollen morphology to develop a cladogram of the Papilionoideae. Povorov (1994) distinguished Fabaceae sub-families by examining nodulation, and Doyle (1994) combined nodulation patterns with morphology and molecular patterns in describing Papilionideae phylogeny. There are several reports of the use of nucleic acids to find patterns within the Fabaceae generally, and the Papilionoids in particular (Doyle *et al.* 1992, Badr *et al.* 1994, Liston and Wheeler 1994, Lavin and Doyle 1992, Martin and Dowd 1993). Allen and Allen (1981) did not explain their methods of relating the Fabaceae, but their work on the group is widely respected. There is, fortunately, a convergence of consensus that lupines are the most closely related genera of North American natives to *Cytisus*. *Thermopsis* and *Sophora* are usually considered the next most closely related genera. The major divisions of North American Papilionideae are represented in Figure 1, along with representative genera found in North America.

Many important food and crop species are found in the non-Genistaea Papilionoids, but none in the Cytisus-Genista complex. Within the Genistaea, there are some species of minor importance - grain lupines and several ornamentals. All the Cytisus-Genista species are introduced from the Old World. *Laburnum* spp., the golden-chain tree, *Genista* spp. and *Cytisus* spp. are grown and sold as ornamentals in Oregon (Oregon Association of Nurserymen 1997) and *Petteria ramentaceae* and *Calycotome* spp. are listed in encyclopedias or dictionaries of North American horticultural plants (Bailey 1939, Bailey *et al.* 1976).

## C. Distribution of Scotch broom.

Native to Europe and Asia, Scotch broom has been introduced into and established in Australia, eastern and western Canada, Chile, India, New Zealand and eastern and western U.S. (Holm et al. 1979, Hosking *et al.* 1996, Luken and Thieret 1997). Its native region extends from Sweden in the north to southern Spain and the Azores, and from Ireland in the west to west central Ukraine (Tutin *et al.* 1968). It is known in Canada from the provinces of British Columbia, Nova Scotia and Prince Edward Island, and in the U.S. from the states of Alaska, California, Connecticut, Delaware, Georgia, Hawaii, Maryland, Maine, Montana, North Carolina, New Jersey, New York, Ohio, Oregon, Pennsylvania, South Carolina, Tennessee, Utah, Virginia, Washington and West Virginia (Luken and Thieret 1997).

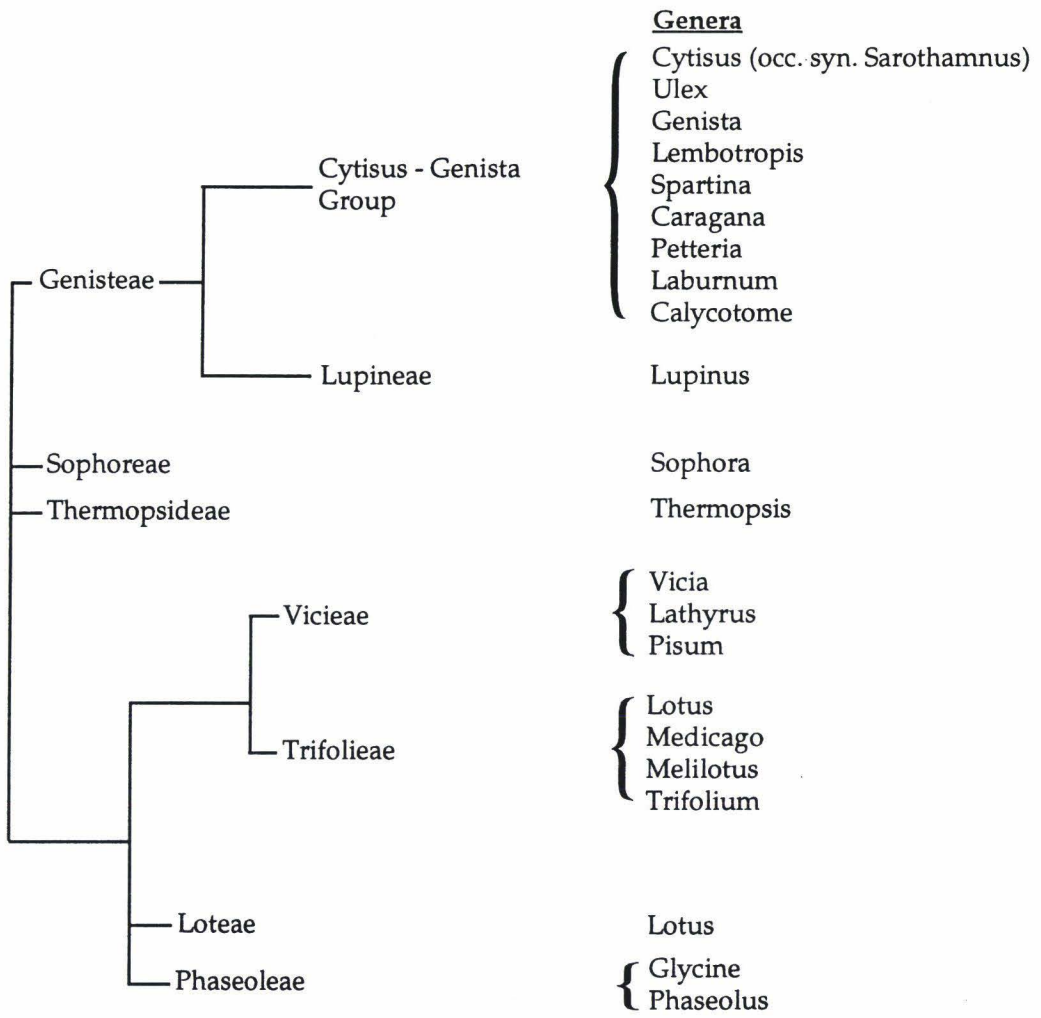
The first records of Scotch broom in the west are from the late 1880's, and broom has steadily increased its range from then to the present (see Figure 2). The current extent of Scotch broom in the western U.S. is illustrated in Figure 3

## D. Distribution of taxonomically related plants.

As mentioned above, all the plants in the Cytisus-Genista group are introduced; most are ornamentals. The lupines are the the most closely-related group, and there are many spe-

# Figure 1

Figure 1. - Hypothesized phylogenetic relationships of common genera of Papilionoideae found in northern California and the Pacific Northwest west of the Cascade Mountians.[1]




[1]Condensed from Bisby, F.A. 1981. Tribe 32 - Genisteae. In: Polhill, R. M. and P. H. Raven, eds. Advances in Legume Systematics, pp. 409-425; and from Doyle, J. J., M. Lavin, and A. Bruneau. 1992. Contributions of Molecular Data to Papilionoid Legume Systematics. In: Soltis, P. S., D. E. Soltis, and J. J. Doyle, eds. Molecular Sytematics of Plants, pp. 223-251.

cies, both annuals and perennials. Hitchcock and Cronquist (1973) list 23 species of lupines for the Pacific Northwest, and Riggins and Sholars (1993) list 71 species in California, and the lupines are distributed U.S.-wide.

## E. Life history of Scotch broom.

Scotch broom germinates when both adequate moisture and heat are available, usually spring and fall in the western U.S. Plants may flower and fruit in the second year, blooming March through May. Scotch broom can be self-pollinating, but most seed is produced with outcrossing (Parker 1996). Pods, each containing ten or more primordia, grow from spring until early summer, reaching a length of 1-3". Pods turn from green to dark brown upon maturing in mid-summer, and as they dry, they twist and and finally dehisce, flinging seed several feet. A majority of the seed are covered by a hard coat which prohibits water uptake and may delay germination for months or years (Bossard 1993). Individual plants may live twenty years more or less, though longevity in broom's native range is shortened, apparently by the large number of herbivores attacking it (Waloff and Richards 1977, Rees and Paynter 1997). Parnell (1966) gives a detailed life history of Scotch broom.

## F. Impacts of Scotch broom.

Dense stands of Scotch broom prevent establishment of native and desirable plant species. This is particularly true in forest settings, where broom interferes with reforestation efforts (Balneaves 1992), and in pastures (Goeden 1978), where effective grazing area is reduced. In natural settings, broom may compete with nitrogen-fixing natives, and this is especially troublesome in the case of the threatened *Lupinus sulphureus* subsp. *kincaidii*, which is the primary host of another threatened species, Fender's blue butterfly (*Icaricia icarioides fenderi*).

Dense stands of Scotch broom also cause safety problems. Broom is often seen along roadways, and can grow to 8-10 feet or more in height, and this can create sight-safety hazards, particularly at intersections, driveways and along curves. It is also a fire hazard (Goeden *op. cit.*), and like gorse, can be a fuel source for quick-burning fires. Scotch broom contains many secondary plant compounds, including alkaloids (Mears and Mabry 1971) and flavenoids (Harborne 1971), which have biological activity in animals, including humans. In some cases these compounds can be expoited for medicinal use, but they can also cause undesirable effects, such as abortion in foraging animals.

Scotch broom releases large amounts of pollen, and this can be a problem for hay fever sufferers. The Oregon Department of Transportation formerly planted Scotch broom and some broom hybrids in roadside ornamental plantings, but this practice was stoppped because, among other things, of complaints about exposure to pollen by travellers.

Scotch broom, mainly because of its capability to fix nitrogen and thus establish on nitrogen-poor substrates, can alter successional outcomes (Waterhouse 1988). In the western U.S., for example, broom has been planted to stabilize sand dunes successfully. Broom has been able to grow to maturity in many such areas, not only those where it has been planted,

Figure 2. - After initial introduction in the 1880's Scotch Broom has continued to expand its range in (a) Oregon, and (b) in the Pacific Northwest (Rice, 1997).

**Figure 2a**

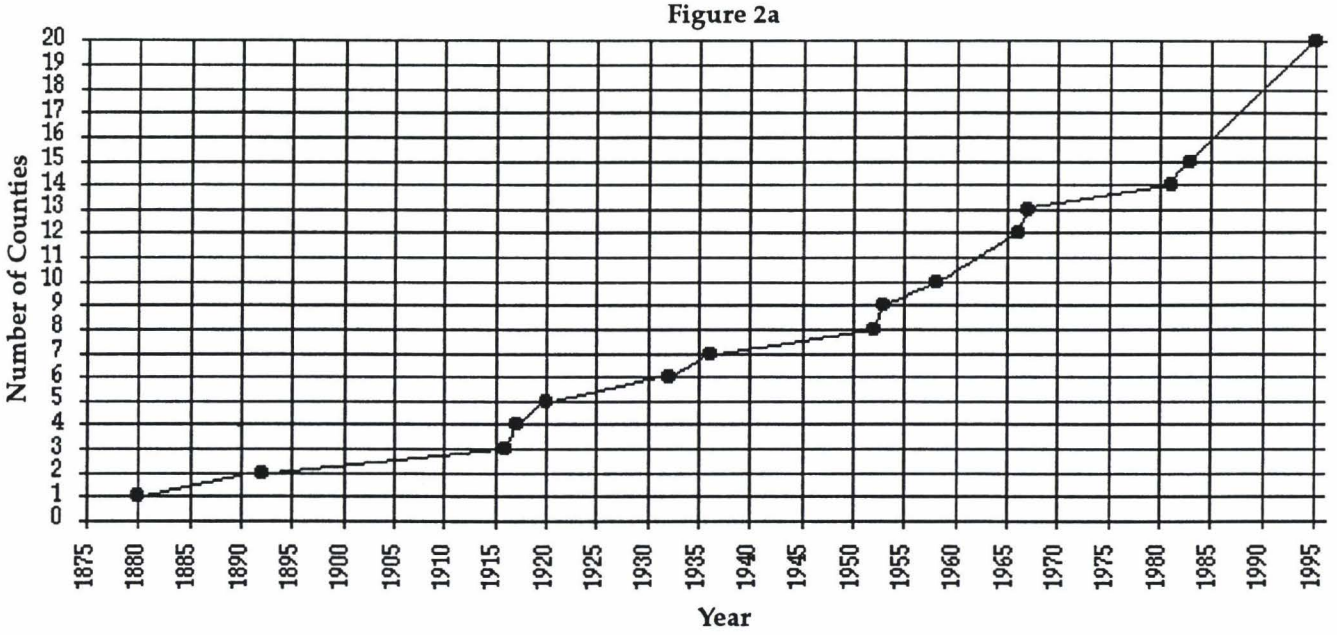



**Figure 2b**

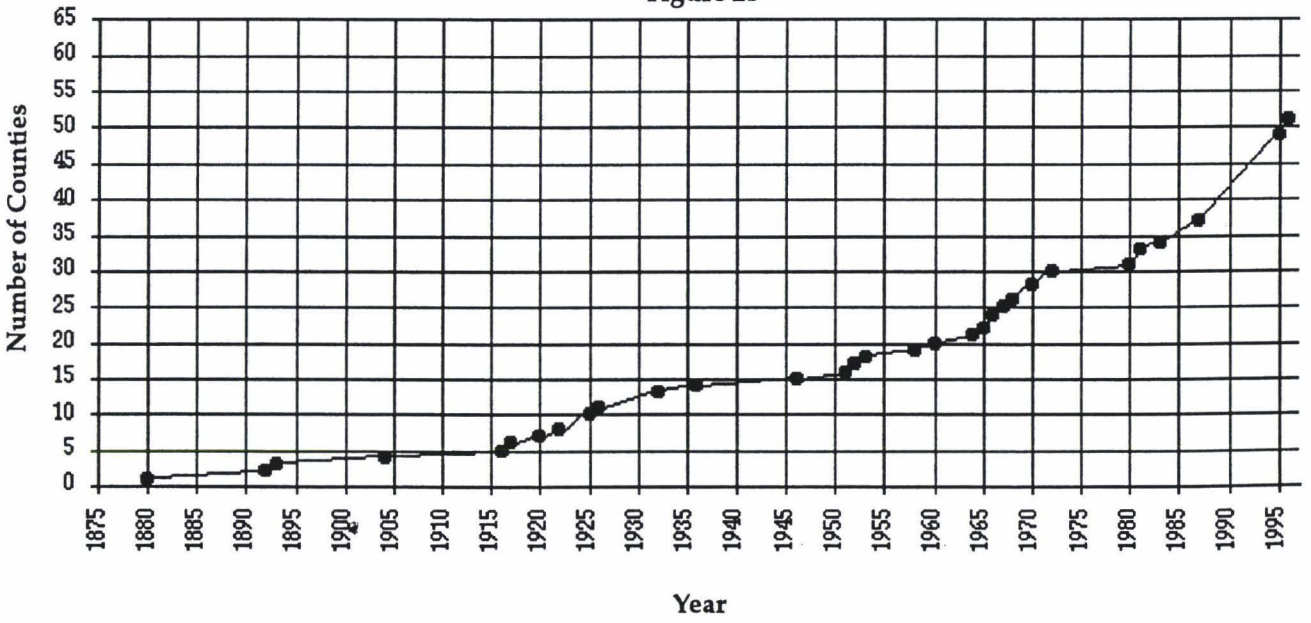
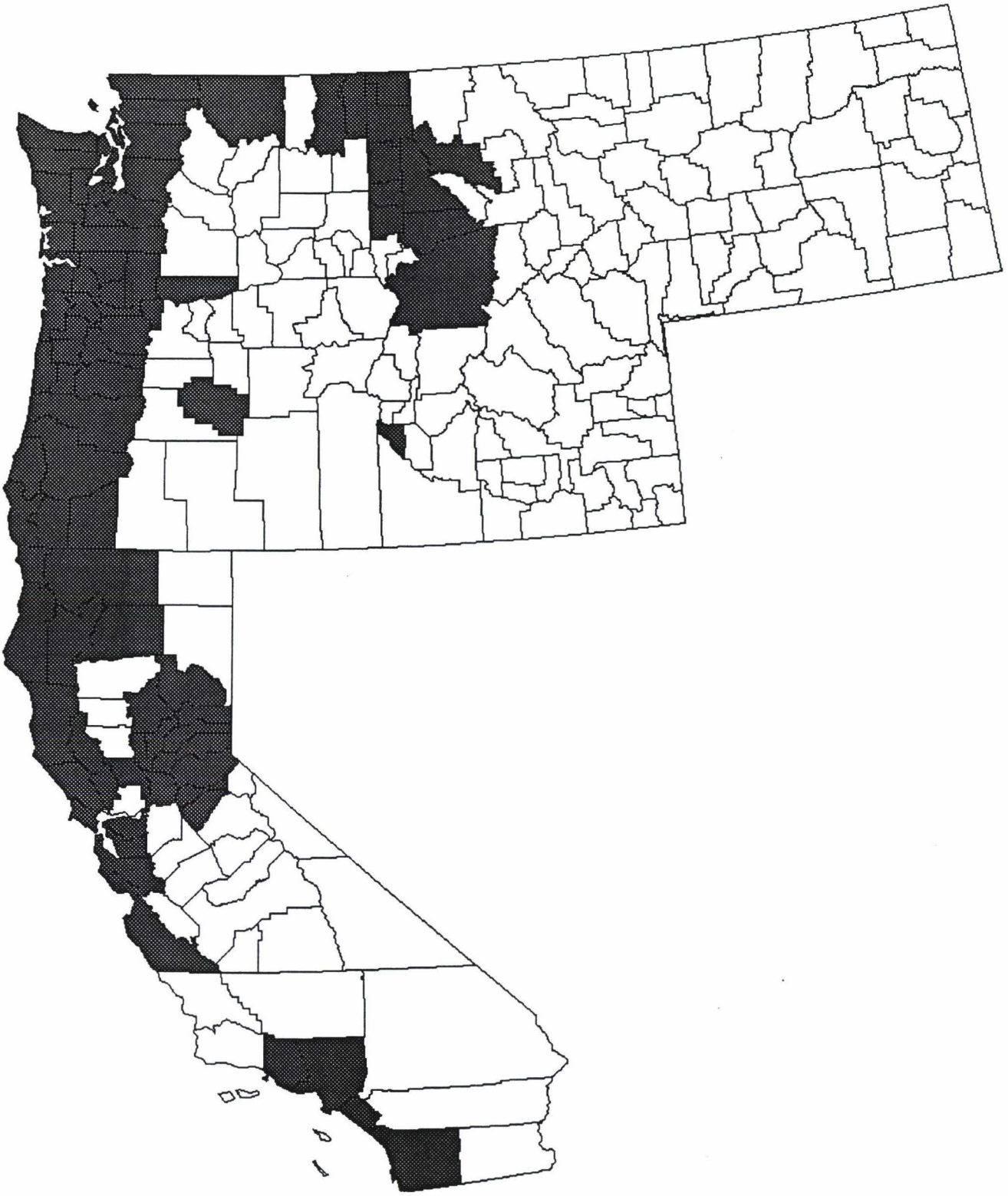


Figure 3. - Current broom distribution in the western United States (Rice, 1997)



and it reduces velocity of sand-moving winds and allows establishment of other vegetation. This impact can be considered either positive or negative, but, on balance, there is likely a consensus that broom is a net detriment in most dune areas.

There are some benefits of Scotch broom. Several nurseries in Oregon and Washington produce and sell broom varieties that have *C. scoparius* in their parentage (OAN 1997), and nurseries also import liners of broom from Europe for resale. Broom is valued for its showy flowers, for its capacity to serve as a visual screen and for its ability to persist with a minumum of maintenance. Bees occasionally visit Scotch broom, but pollen and nectar are not in short supply during the time broom is blossoming.

### G. Alternative management options.

Biological control can be thought of as a preventative measure. Broom spreads locally mainly by throwing seeds when pods dehisce, contributing to spread, and an 80% reduction in seed production might be reduce rates of local spread by 35-80% (Paynter *et al.* 1996). Long range dispersal can be limited by denying association of seed with dispersing agents - vehicles, humans, domestic animals, earth-moving equipment. etc., but in practice this is very difficult.

Plants can be controlled manually by pulling or grubbing out the crowns, and after removal, cultivation will destroy seedlings. Rotations of improved pastures into cultivation for 1-2 years will reduce a broom problem. Mowing reduces seeding, although it also encourages branching and may result in a thick mat of short broom plants. Cutting is most effective when plants are water-stressed, but some resprouting is expected. Selective control by herbicides is effective but usually requires followup treatment. Thorough wetting of the plants is required, and wetting agents improve results.

Mechanical and chemical control require intensive effort and considereable resources, and this contrasts strongly with control by biological control if it is successful. In many areas in California, Oregon and Washington now, use of intensive measures is precluded by restricted budgets of land management agencies.

## III. Biological Control Agent Information

### A. Occurrence in eastern U.S.

*Bruchidius villosus* was apparently the first *Bruchidius* to become established in North America (Bottimer 1968). It was first collected in 1918 at Wood's Hole, Massachusetts by C.E. Olsen, but, after originally having been thought to be a native, *Bruchus calvus*, this collection was identified as *Bruchidius ater* (Marsham) by J.C. Bridwell (Southgate 1963, Bottimer *op. cit.*). As of 1968, its distribution was

> ...currently known only from the Northeastern United States, [but] *B. ater* can be expected to follow its host southward from Virginia and possibly northward into the Maritimes where the host plant is able to thrive, and eventually to be introduced into the West Coast colonies of the Scotch broom. (Bottimer *op. cit.*).

## B. Taxonomy.

Southgate (1963) corrected errors by Bridwell, who had first called the original specimen *B. ater*, but then renamed it *B. villosus* in 1938 (Bottimer *op. cit.*). Bottimer accepted Southgate's determination that *B. ater* was the proper name for the bruchid found established on broom in the U.S., but he also concluded that *B. ater* (Marsham) and *B. villosus* (Fabricius) were distinct. Part of this confusion can be explained by the fact that *Bruchidius* is an Old World genus, and Bridwell re-described specimens without direct access to type specimens. (He relied on a correspondent in Europe.)

The confusion has carried over into scientific reports on *B. villosus* and *B. ater*. Frick (1962), working before Southgate published, used *B. villosus* for material he collected and worked with from Virginia, Delaware, Maryland and the "northeastern U.S." Parnell (1964, 1965, 1966), aware of Southgate's work, used *B. ater*, presumably for the same species. New Zealand researchers (see Syrett and O'Donnell 1987, e.g.) and Australians (see Wapshere and Hosking 1993, e.g.) used *B. villosus*.

Concerned about possible confusion of *B. ater* and *B. villosus*, Dr. George Markin of the U.S. Forest Service Rocky Mountain Research Station in Bozeman, Montana collected specimens from the population in North Carolina that would be the source for material introduced to the western U.S., and sent them to the USDA-ARS Systematic Entomology Laboratory (SEL) in Beltsville, MD for identification. He also acquired specimens from New Zealand and sent them to SEL. Dr. J.M. Kingsolver, a Bruchid specialist now retired from SEL, determined both collections were *B. villosus* by dissection of male genitalia and comparison with a known specimen of *B. villosus*. Additionally, Dr. Markin sent North Carolina collections of *B. villosus* to the Insect Identification Service of the CABI International Institute of Entomology in London, U.K., who also determined that the specimens were *B. villosus* (determined by M.L. Cox, IIE).

To confirm the identity of the New Zealand and North Carolina *B. villosus*, Dr. Markin oversaw an isozyme analysis conducted by Dr. Robert Nowierski, Department of Entomology, Montana State University. Dr. Nowierski's conclusion was that

> The two populations show a Nei's (1972) genetic distance of approximately 0.05, which would be a typical genetic distance for two closely related populations of the same species. In our opinion this small degree of genetic distance would imply that these two populations are the same species with only slight genetic divergence. In spurge and curculionids (*Gymnetron* spp.) on Dalmatian toadflax the genetic distance typical of different species ranged from 0.70 to 1.1 (Nowierski *et al.* 1966, McDermott *et al.* submitted). Because these two *Bruchidius* populations are genetically so close, you should be able to use previous host-specificity data from either population for screening and petition development.

## C. Geographic range.

Syrett and Emberson (1997) collected *B. villosus* in the U.K., France, Portugal and Spain. If the identifications in Frick's (1962) report are accurate, *B. villosus* is also native to Austria, Denmark, Germany, Hungary, Italy and Switzerland. Given the extensive native range of *B. villosus* and its apparently extensive range in the eastern U.S., this speicies should be expected to survive in any area that its host does.

## D. Known host range.

In addition to *Cytisus*, Bottimer (1968), suggests that four distinct species of *Bruchidius, B. ater, B. cisti, B. fasciatus* and *B. villosus*, are known from *Calycotome, Genista, Laburnum, Lembotropis, Petteria* and *Sarothamnus*, all members of the Genista-Cytisus group (refer to Figure 1). Syrett and Emberson (1997) sampled for various beetle species on all Genisteae species found at 14 sites in 1989 and 28 sites in 1992 in France, Spain, Portugal and the U.K. while most plants were in full flower. *B. villosus* was collected from *C. scoparius, C. striatus, C. cantabricus* and *Spartium junceum*, all Genisteae, but not from 10 other representatives of the group. Frick (1962) searched records of interceptions at U.S. ports of entry at the U.S. National Museum of infested seeds, and *B. villosus* was found on several *Cytisus* spp., three *Genista* spp., including *G. monspessulanus, Laburnum* spp. and *Spartium junceum*. He also found records of *B. villosus* being reared in the U.S. from *C. scoparius, Laburnum alpinum* and *Petteria ramentacea*. There are no records of *B. villosus* attacking any species outside the Genista-Cytisus group, either in the U.S. or in Europe, other than adults using gorse pollen early in the season before natural host flowers are available, or using pollen of yarrow and velvetgrass when they occur in areas with broom (Parnell 1966).

## E. Life history.

Parnell (1966) provides a detailed life history of *B. villosus* (as *ater*). This beetle overwinters as an adult, not necessarily in areas associated with broom. Sexually immature adults emerge from hibernation in March and April, and, in England, aggregate on flowering gorse and feed on pollen (Parnell *op.cit.*). As broom comes into bloom, adults move from gorse to broom and continue to feed on pollen. Adult females begin oviposition when young green pods of broom develop. Eggs are laid only on the outsides of the pod, and are cemented to the pod surface. On hatching, larvae chew into the pod cavity and attack a soft green seed. There are four larval instars, and one larva will use one seed, and pupate within the seed coat. After a short pupation period, adult beetles emerge from the seed, but stay within the pod until dehiscence, then disperse to overwintering sites.

## F. Populations of agent studied.

There have been three separate sets of tests of populations for oviposition as an indicator of host specificity, one by Frick (1962) on insects collected near Kirkwood, Delaware, one by Syrett and O'Donnell (1987) on material from Silwood Park in the U.K., and one by Dr. Jeff Littlefield on *B. villosus* collected near Asheville, North Carolina.

### 1. Delaware collection.

Dr. Frick conducted "no-choice" tests in 1 x 5" shell vials and gallon jars, and "choice" tests in gallon jars and 15 x 15 x 18" cages. In the "no-choice" tests in vials, 10-20 adults were placed in each of the vials for 48 hours with pods of broom, locust (*Robinia pseudoacacia*), vetch (*Vicia villosa*), peas (*Pisum sativa*) and beans (*Phaseolus vulgaris*). More eggs were laid on the vials than on the pods of the test species. Twenty adults were placed for 48 hours in three different gallon jars, one each with broom, locust and vetch. Only one egg was placed on a vetch pod in this experiment, many were placed on broom. In the

"choice" tests in gallon jars, 34 *B. villosus* adults were placed on bouquets of the same five legumes as in the "no-choice" vial test. Most eggs were laid on broom, but some were placed on vetch and locust. In the cage experiment, several hundred adults were placed in a 15 x 15 x 18" cage for 48 hours with broom, locust, golden-chain (*Laburnum anagyroides*) and vetch, and eggs were laid on all species, though the most were laid on broom. Frick's data are summarized in Tables 1 through 4.

**2. New Zealand study of U.K. *B. villosus*.**
New Zealand researchers conducted "no choice" studies on caged whole plants or on sleeved portions of whole plants on 14 species of legumes, where only one species was available per cage or sleeve for oviposition. Tests ran for four weeks, and no eggs were laid on any species except Scotch broom. They conducted two "choice" experiments. In one, two potted plants each of broom and of a test species were placed in a 0.5 x 0.5 x 2.5 meter cages with 200 beetles for four weeks, and in the other 10 beetles were placed in 0.22 x 0.13 x 0.10 meter cages with one cut shoot each of broom and a test species. There were seven non-broom species incorporated in the former test, and nine in the latter. In neither case was there any oviposition on any species other than broom. New Zealand tests are summarized in Tables 5 through 7.

**3. Montana study of North Carolina *B. villosus*.**
Dr. Litttlefield at Montana State University also conducted both "no-choice" and "choice" tests. Two lupine species, French broom (*Genista monspessulanus*) and another legume, *Caragana* sp., were each placed in clear acetate tubes 10cm in diameter and 13 cm long with 10 adult *B. villosus* for 17 days. There was no oviposition on any of these species. In "choice" tests, eight beetles were placed in the tubes with cut stems of broom and a test species each for 7 days. Beetles laid eggs only on Scotch broom. A summary of the "choice" test results are presented in Table 8.

# IV. Potential Environmental Impacts

## A. Human.
Should biological control be successful, the main human impact would be the reductions in reactions to Scotch broom pollen. While there are no known cases of acute exposure and illness to herbicides, successful biological control would minimize human exposure to herbicides.

## B. Economic.
The economics of Scotch broom is understood only in qualitative terms. Biological control would provide substantial economic return in situations where there are now no alternative control methods, mainly in areas where the use of herbicides is uneconomic or not allowed.

## C. Plant.
Native and desirable plant species would benefit from successful biological control of Scotch broom through reduced competition.

# Tables 1 - 2

Table 1. "No-choice" tests of Delaware *Bruchidius villosus* in 1 x 5" vials conducted by Frick (1962). Adults were exposed to plant material for 48 hours.

| Test plant | No. of pods | No. of beetles | Eggs laid: On vials | Eggs laid: On pods |
|---|---|---|---|---|
| *Cytisus scoparius* (Scotch broom) | 12 | 20 | 4 | 70 |
| *Robinia pseudoacacia* (locust) | 12 | 20 | 17 | 1 |
| *Vicia villosa* (vetch) | 12 | 20 | 12 | 36 |
| *Pisum sativa* (garden pea) | 1 | 10 | 44 | 0 |
| *Phaseoleus vulgaris* (green bean) | 1 | 10 | 43 | 0 |
| | Totals | | 120 | 107 |

Table 2. "No-choice" tests of Delaware *Bruchidius villosus* in gallon jars conducted by Frick (1962). Adults were exposed to plant material for 48 hours.

| Test plant | No. of pods | No. of beetles | Eggs laid: On vials | Eggs laid: On pods |
|---|---|---|---|---|
| *Cytisus scoparius* (Scotch broom) | 3 | 20 | 0 | 141 |
| *Robinia pseudoacacia* (locust) | 10 | 20 | 9 | 0 |
| *Vicia villosa* (vetch) | 9 | 20 | 1 | 1 |

# Tables 3 - 4

Table 3. "Choice" tests of Delaware *Bruchidius villosus* with five test species placed in a gallon jar with 34 adults, conducted by Frick (1962). Adults were exposed to plant material for 48 hours.

| Test plants | No. of pods | Eggs laid on pods |
|---|---|---|
| *Cytisus scoparius* (Scotch broom) | 7 | 341 |
| *Robinia pseudoacacia* (locust) | 9 | 2 |
| *Vicia villosa* (vetch) | 9 | 14 |
| *Pisum sativa* (garden pea) | 1 | 0 |
| *Phaseoleus vulgaris* (green bean) | 1 | 0 |

Table 4. "Choice" tests of Delaware *Bruchidius villosus* with five test species placed in a 15 x 15 x 18" cage with several hundred adults, conducted by Frick (1962). Adults were exposed to plant material for 48 hours.

| Test plants | No. of pods | Eggs laid on pods |
|---|---|---|
| *Cytisus scoparius* (Scotch broom) | 7 | 382 |
| *Robinia pseudaoacacia* (locust) | 7 | 215 |
| *Laburnum anagyroides* (golden-chain) | 7 | 30 |
| *Vicia villosa* (vetch) | 7 | 8 |

# Table 5

Table 5. "No-choice" tests of *Bruchidius villosus* from Silwood Park, U.K. on whole plants or sleeved branches, conducted by Syrett and O'Donnell (1987). Adults were exposed to plant material for four weeks.

| Test plant | No. of pod | No. of beetles | Eggs laid on pods |
|---|---|---|---|
| Genisteae | | | |
| 1. Genista-Cytisus group: | | | |
| *Cytisus scoparius* (Scotch broom) | 110 | 10 | 70 |
| *Genista hispanica* | 90 | 5 | 0 |
| *Genista pilosa* | 4 | 5 | 0 |
| *Ulex eurpoaeus* (gorse) | 60 | 5 | 0 |
| *Laburnum anagyroides* (golden-chain) | 90 | 20 | 0 |
| 2. Lupineae | | | |
| *Lupinus arboreus* (tree lupine) | 3 | 5 | 0 |
| Trifolieae | | | |
| *Medicago sativa* (alfalfa) | 8 | 5 | 0 |
| *Trifolium dubium* (hop clover) | 479 | 10 | 0 |
| Vicieae | | | |
| *Vicia faba* (horse-bean) | 1 | 5 | 0 |
| *Vicia hirsuta* (common vetch) | 113 | 10 | 0 |
| *Vicia sativa* (spring vetch) | 43 | 10 | 0 |
| Glycininae | | | |
| *Glycine max* (soybean) | 12 | 5 | 0 |
| Pnaseolinae | | | |
| *Phaseoleus vulgaris* (green bean) | 17 | 5 | 0 |
| Coronillae | | | |
| *Coronilla varia* (crown vetch) | 21 | 10 | 0 |

# Table 6

Table 6. "Choice" tests of *Bruchidius villosus* from Silwood Park, U.K. on whole plants, conducted by Syrett and O"Donnell (1987). Two hundred adults were exposed to plant two plants each of the test species and of Scotch broom for four weeks.

| Test plant | No. of pods | No. of beetles | Eggs laid |
|---|---|---|---|
| Genisteae | | | |
| *Cytisus scoparius* (Scotch broom) | 67 | 200 | 351 |
| *Cytisus praecox* v. "Allgold" (ornamental broom) | 10 | 200 | 10 |
| *Genista hispanica* | 137 | 200 | 0 |
| Trifolieae | | | |
| *Medicago sativa* (alfalfa) | 42 | 200 | 0 |
| Vicieae | | | |
| *Vicia faba* (horse-bean) | 6 | 200 | 0 |
| *Pisum sativa* (garden pea) | 5 | 200 | 0 |
| Glycininae | | | |
| *Glycine max* (soybean) | 10 | 200 | 0 |
| Phaseolinae | | | |
| *Phaseoleus vulgaris* (green bean) | 9 | 200 | 0 |

# Table 7

Table 7. "Choice" tests of *Bruchidius villosus* from Silwood Park, U.K. on cut shoots, conducted by Syrett and O"Donnell (1987). Ten adults were exposed to paired offerings of broom and the listed test plants in ventilated 0.22 x 0.13 x 0.10 meter cages six to seven days.

| Test plant | Eggs laid on test plant | Eggs laid on broom |
|---|---|---|
| Genisteae | | |
| *Chamaecytisus palmensi* (fodder broom) | 0 | 187 |
| *Cytisus multiflorus* (ornamental broom) | 0 | 61 |
| *Genista monspessulanus* (French broom) | 0 | 50 |
| Carmichaeliae | | |
| *Carmichaelia petriei* | 0 | 70 |
| *Carmichaelia ovata* | 0 | 61 |
| *Carmichaelia williamsii* | 0 | 21 |
| *Chordospatium stevensonii* | 0 | 21 |
| Galegeae | | |
| *Clianthus puniceus* | 0 | 38 |
| Sophoreae | | |
| *Sophora microphylla* | 0 | 63 |

# Table 8

Table 8. "Choice" tests of *Bruchidius villosus* from Asheville, North Carolina on cut shoots, conducted by Dr. Jeff Littlefield, Department of Entomology, Montana State Univeristy. Eight adults were exposed to paired offerings of broom and the listed test plants with equivalent numbers of pods in ventilated 0.10 meter diameter x 0.13 meter high ice cream cartons for seven days.

| Test plant | Replicates | Eggs laid on test plant | Eggs laid on broom |
|---|---|---|---|
| Genisteae | | | |
| 1. Genista-cytisus group | | | |
| *Genista monspessulanus* (French broom) | 1 | 0 | 70 |
| 2. Lupinieae | | | |
| *Lupinus arboreus* (tree lupine) | 3 | 0 | 171 |
| *Lupinus littoralis* (seaside lupine) | 4 | 0 | 187 |
| *Lupinus arboreus x rivularis* | 4 | 0 | 111 |
| *Lupinus arboreus* (collection 3) | 4 | 0 | 76 |
| *Lupinus arboreus* (collection 4) | 4 | 0 | 72 |
| Vicieae | | | |
| *Pisum sativa* (garden pea) | 1 | 0 | 120 |

### D. Mitigation.
No mitigation is planned or thought to be needed.

### E. Abiotic/Edaphic.
Any abiotic/edaphic impacts of broom control are judged to be minor in relation to other factors, probably not detectable by ordinary measurements.

### F. No action.
Scotch broom is continuing to expand its range and increase in density within its range, and the any impacts related to broom would therefore also increase if there were no control.

## VI. Conclusion and Recommendation

Considerable effort has been expended to determine that *Bruchidius villosus* is not already established in Oregon, because other insects specific to broom have been accidentally introduced (Coombs 1997), and because it seems likely that *B. villosus* may also arrive accidentally in the western U.S. (Bottimer 1968). Carol Horning, a technician with the U.S. Forest Service Mapleton District, collected from broom at more than 125 sites throughout western Oregon in 1996 without finding *B. villosus*. In all the Noxious Weed Control Program's collecting and preparing *Apion fuscrirostre* for redistribution, no *B. villosus* has been found.

If approval for release is forthcoming, North Carolina material will be checked for parasites and diseases at the quarantine facility on the campus of Montana State Univeristy in Bozeman. Earlier shipments of *B. villosus* were found to be free of parasites, but nine of 139 individuals had bacteria associated with them, typical of "...indications of stressed populations which had been stored for long periods of time without proper food. These ... exhibited lack of body fat." (personal communication, Dr. George Markin).

It is recommended that approval to import the seed beetle *Bruchidius villosus* from North Carolina to Oregon for release and distribution be granted.

The risks of doing so are minimal, and reside mainly in the unlikely use of *B. villosus* of native lupines in the western U.S. The extensive review of the host range of this beetle by Syrett and Emberson (1997) within its native range established that it uses only a few *Cytisus* spp., and, given the adults' need for early season pollen, their collections of non-*scoparius* *B. villosus* may not have been indicative of a broader actual host range. The range of the beetle in the eastern U.S. also suggests that species outside the Genista-Cytisus will not be hosts, and tests of the North Carolina and U.K. populations of *B. villosus* confirm the restriction of this insect to broom, even to the exclusion of other species within the Genista-Cystisus group. Risks from broom itself to western lupines may well be much greater than risk of release and distribution of *B. villosus*. Oviposition by *B. villosus* on vetch in Frick's tests begs an explanation, but the two most likely ones are that either there

are population differences with the other tested *B. villosus* material, or that that there have been misidentifications of collections and specimens. By restricting collection for import to that tested from Asheville, NC, this issue is avoided.

*Bruchidius villosus* can reasonably be expected to compete with *Apion fuscirostre*, the seed weevil already widely established when either or both of the agents become abundant in relation to the supply of broom pods and seeds. This is a natural result of the desired outcome, reduction of seed production by broom to near zero. European research suggests both that the seed-attacking species can survive in the presence of each other and that substantial reductions in seed production may be required to affect the distribution of broom in areas where it invades.

If permission is granted to import and release *Bruchidius villosus* in Oregon is granted, monitoring will commence with the initial releases and continue for about three years for the purpose of documenting successful establishment and increase in population numbers. After about three years, monitoring of *B. villosus* will be integrated with monitoring currently underway for *Apion fuscrostre*, namely seed bank size, seed production and proportion of pods attacked. Consideration will be given to incorporating *Laburnum* spp. into monitoring efforts to confirm host specificity

## VII. Acknowledgments

Several persons made contributions to the development of the petition to import and release *Bruchidius villosus* in the western United States. Carol Horning, USFS, collected field data and plant materials; Dr. George Markin, USFS, funded support at Montana State University and field work in Oregon and coordinated collections and studies of *B. villosus*, Dr. Peter Rice and Chris Toney provided queries of the Invaders Database, Drs. Jack Coulson and Joe Balciunas, USDA-ARS, provided copies of historical records and correspondence, and Drs. Pauline Syrett, John Hosking, Simon Fowler, and Quentin Paynter provided reports of their research on biological control of broom. Steve Schoenig, California Department of Food and Agriculture, provided an update on broom distribution in California. These contributions are gratefully acknowledged. The Bureau of Land Management, Bonneville Power Administration and the U. S. Forest Service Region Six provided partial funding support, and these contributions are also gratefully acknowledged.

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A permit can be issued to move live plant pests or noxious weeds until an application is received (7 CFR 330.(live plant pests) or 7 CFR 360 (noxious weeds)).

FORM APPROVED - OMB NO. 0579-0054

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE
BIOLOGICAL ASSESSMENT SUPPORT STAFF
HYATTSVILLE, MARYLAND 20782

# APPLICATION AND PERMIT TO MOVE LIVE PLANT PESTS AND NOXIOUS WEEDS

**SECTION A - TO BE COMPLETED BY THE APPLICANT**

1. NAME, TITLE, AND ADDRESS (Include Zip Code)

Dennis Isaacson, Special Projects Coordinator
Oregon Department of Agriculture
635 Capitol St NE
Salem, OR 97310-0110

JUN 16 1998

2. TELEPHONE NO.

3. TYPE OF PEST TO BE MOVED

☒ Arthropods ☐ Noxious Weeds
☐ Pathogens ☐ Other (Specify)

| A. SCIENTIFIC NAMES OF PESTS TO BE MOVED | B. CLASSIFICATION (Orders, Families, Races or Strains) | C. LIFE STAGES IF APPLICABLE | D. NUMBER OF SPECIMENS OR UNITS | E. SHIPPED FROM (Country or State) | F. ARE PESTS ESTABLISHED IN U.S. | G. MAJOR HOST(S) OF THE PEST |
|---|---|---|---|---|---|---|
| 4. Bruchidius villosus | Bruchidae | Adult | 5,000 | NC (via MT) | Yes | Scotch Broom (Cytisus scoparius) |
| 5. | | | | | | |
| 6. | | | | | | |

7. WHAT HOST MATERIALS WILL ACCOMPANY WHICH PESTS (Indicate by line number)

| 8. DESTINATION | 9. PORT OF ARRIVAL | 10. APPROXIMATE DATE OF ARRIVAL OR INTERSTATE MOVEMENT |
|---|---|---|
| Oregon | Salem | Summer, 1998; Summer, 1999 |

| 11. NO. OF SHIPMENTS | 12. SUPPLIER | 13. METHOD OF SHIPMENT |
|---|---|---|
| 1-10 | Bozeman, MT George Markin, USFS Rocky Mtn Res Stn | ☒ Air Mail ☒ Air Freight ☐ Baggage ☐ Auto |

14. INTENDED USE (Be specific, attach outline of intended research)
Field release as biological control agent for Scotch broom (Cytisus scoparius)

| 15. METHODS TO BE USED TO PREVENT PLANT PEST ESCAPE | 16. METHOD OF FINAL DISPOSITION |
|---|---|
| Double packed containers designed for live insect shipment | Field release |

17. Applicant must be a resident of the U.S.A. I/We agree to comply with the safeguards printed on the reverse of this form, and understand that a permit may be subject to other conditions specified in Section B and C.

SIGNATURE OF APPLICANT (Must be person named in Item 1)

18. DATE 6/10/98

**SECTION B - TO BE COMPLETED BY STATE OFFICIAL**

19. STATUS
☑ Approve ☐ Disapprove
☐ Accept USDA Decision

20. CONDITIONS RECOMMENDED

| 21. SIGNATURE | 22. TITLE | STATE | 23. DATE |
|---|---|---|---|
| Daniel J. Hilburn | Administrator Plant Division | Oregon | 6/10/98 |

**SECTION C - TO BE COMPLETED BY FEDERAL OFFICIAL**

## PERMIT

24. PERMIT NO. 37997

*(Permit not valid unless signed by an authorized official of the Animal and Plant Health Inspection Service)*

Under authority of the Federal Plant Pest Act of May 23, 1957 or the Federal Noxious Weed Act of 1974, permission is hereby granted to the applicant named above to move the pests described, except as deleted, subject to the conditions stated on, or attached to this application. *(See standard conditions on reverse side).*

Seeds or seed heads are not to be included in the shipments.

CC: OR | WR | SIHD | J. Cowan

| 25. SIGNATURE OF PLANT PROTECTION AND QUARANTINE OFFICIAL | 26. DATE | 27. LABELS ISSUED | 28. VALID UNTIL | 29. PEST CATEGORY |
|---|---|---|---|---|
| Dorothy C. Watson | 8/4/98 | — | 8/31/08 | B2 |

PPQ FORM 526 (MAY 94) Previous edition obsolete.